SESSION
2017-2018

As per the New Semester-wise Syllabus of Gondwana University

Zoology

B.Sc. Semester III (CBCS)

With Practical Manual Inside

Paper - I : ANIMAL DIVERSITY (CHORDATES) AND COMPARATIVE ANATOMY (Core Paper V)

Paper - II : PHYSIOLOGY AND BIOCHEMISTRY - I (Core Paper VI)

Dr. Pankaj R. Chavhan
Dr. Deepak S. Bansod
Dr. Mrs. Nilima V. Umate
Dr. Ganpat D. Deshmukh
Sandesh B. Patharde

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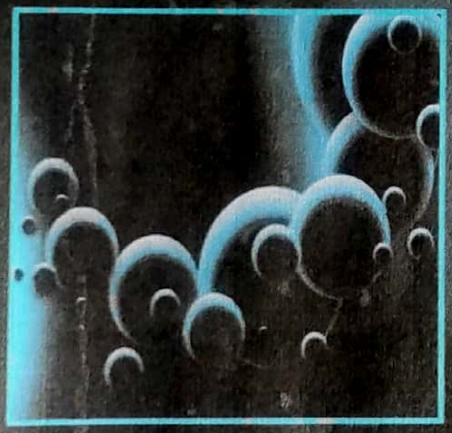

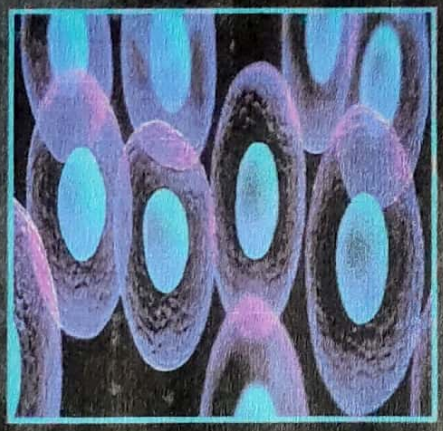

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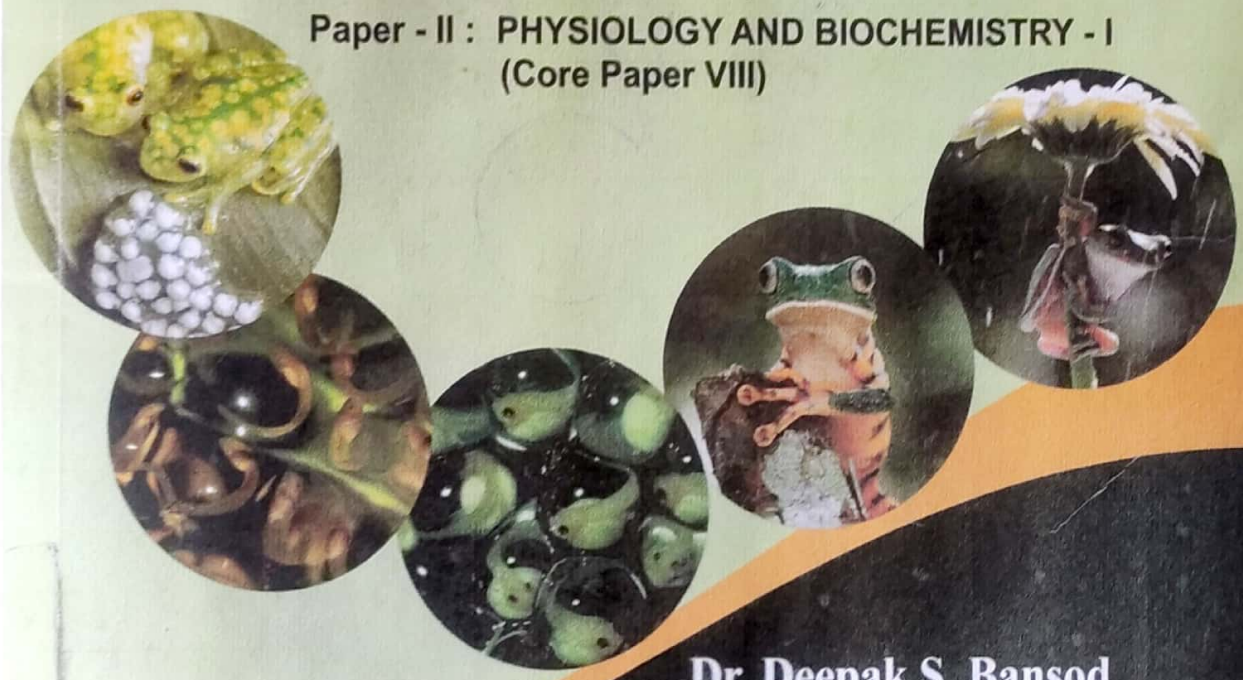

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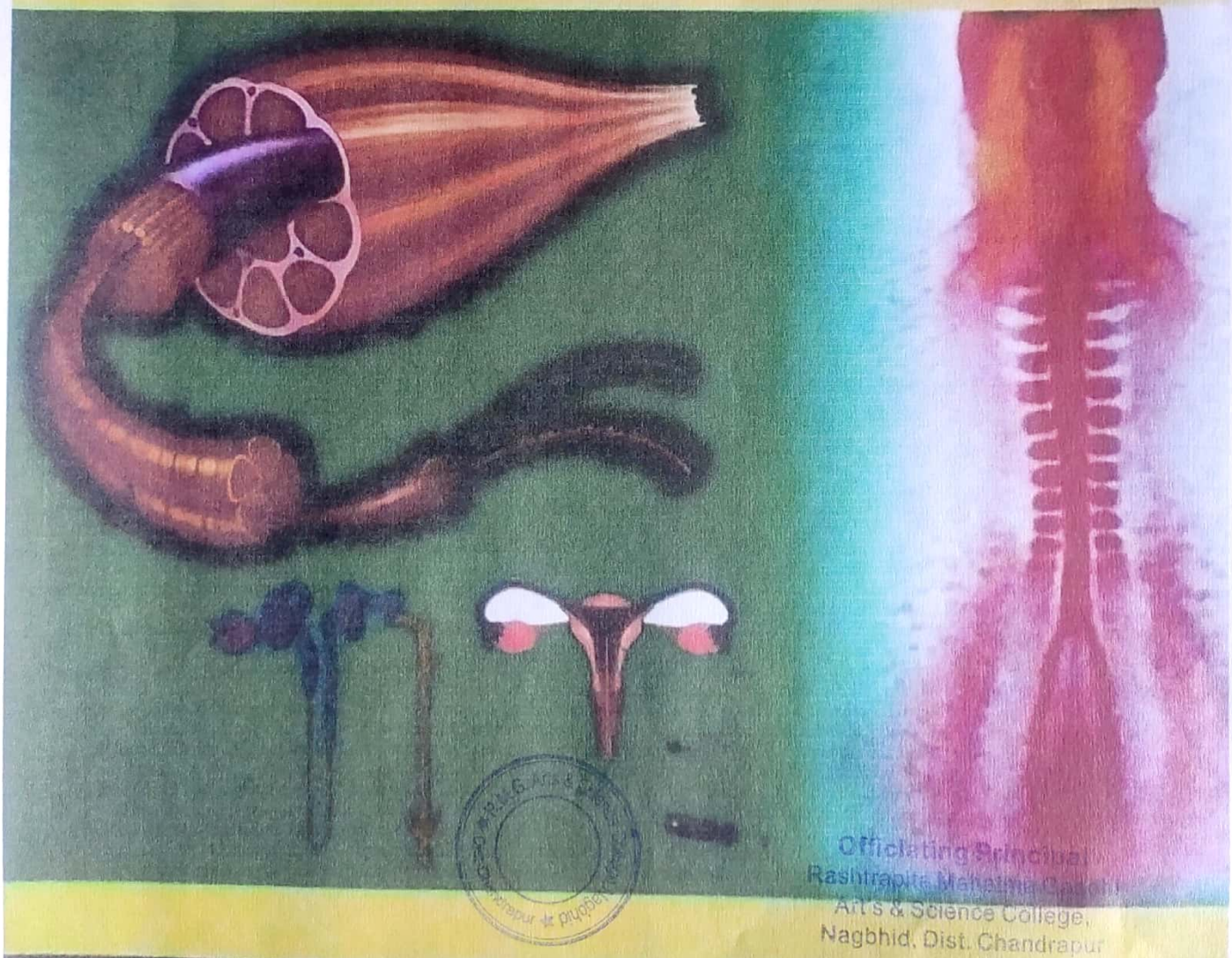

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2019-2020

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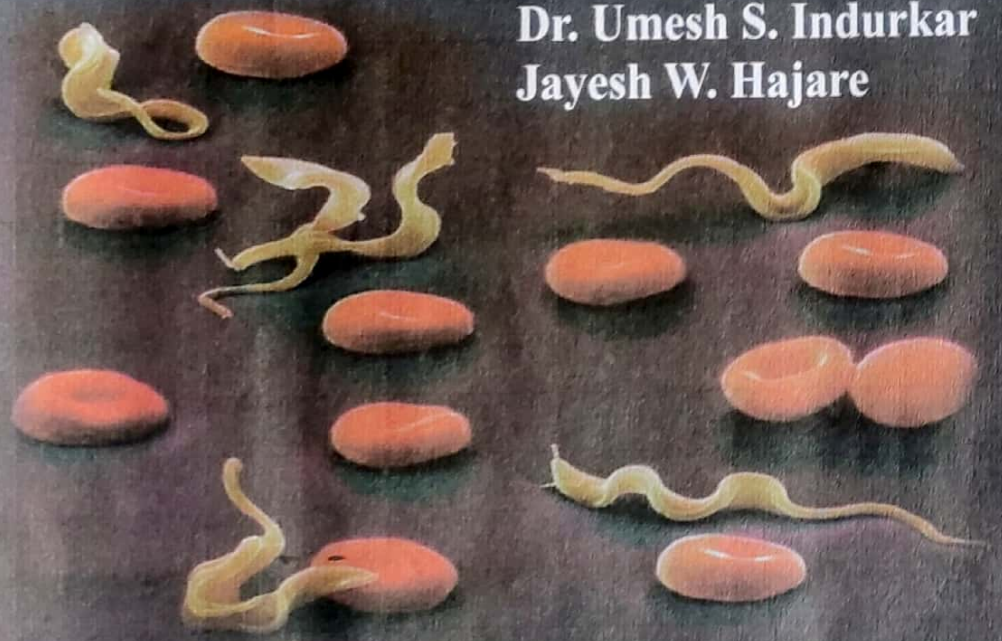
Zoology

B.Sc. Semester V (CBCS)

Paper - I : PARASITOLOGY
DISCIPLINE SPECIFIC ELECTIVES (DSE)
(Core Paper IX)

Dr. Deepak S. Bansod
Dr. Ganpat D. Deshmukh
Dr. Pankaj R. Chavhan
Dr. Umesh S. Indurkar
Jayesh W. Hajare



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B.Sc. Semester V (CBCS)

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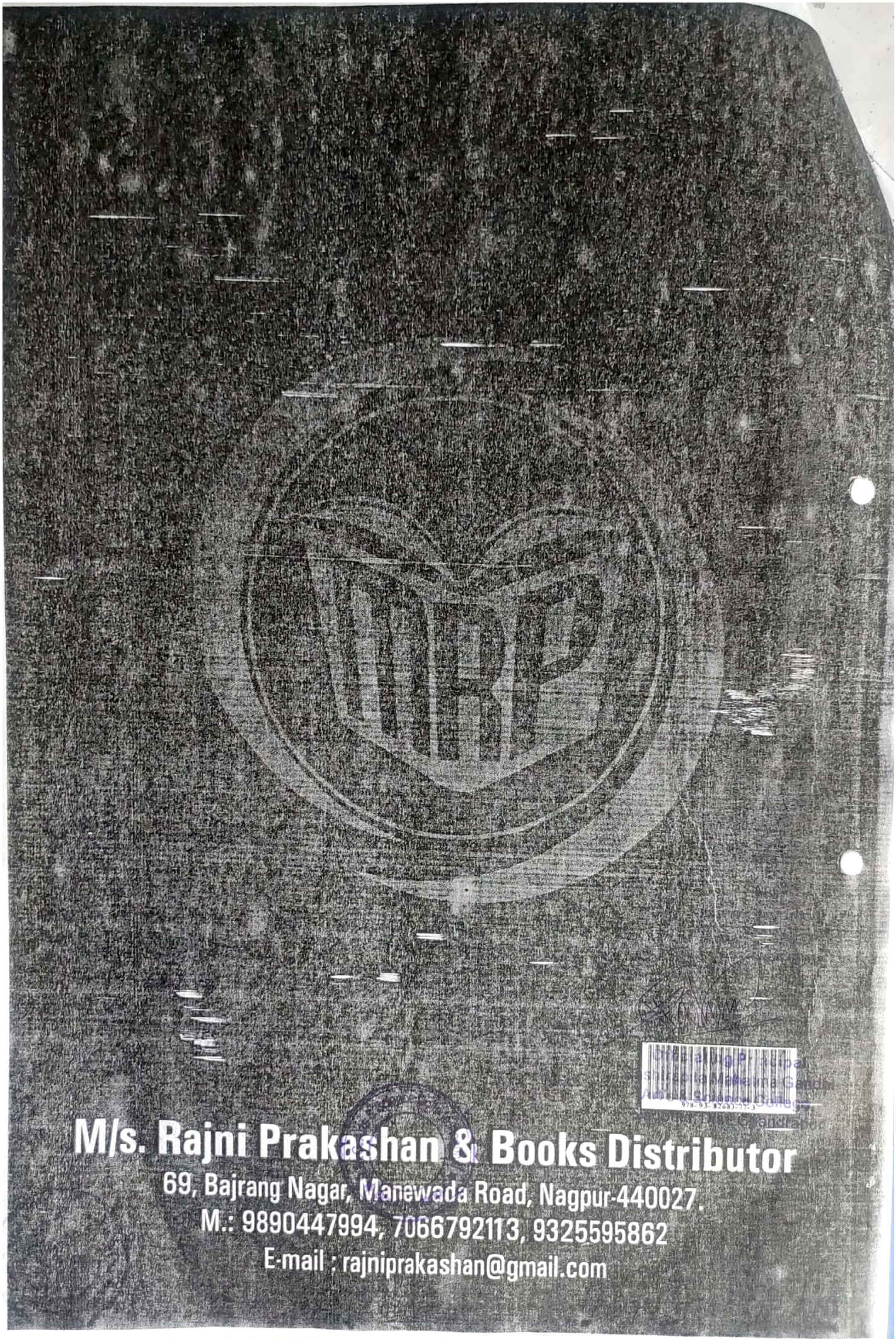

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PAPER - II : PHYSIOLOGY AND BIOCHEMISTRY

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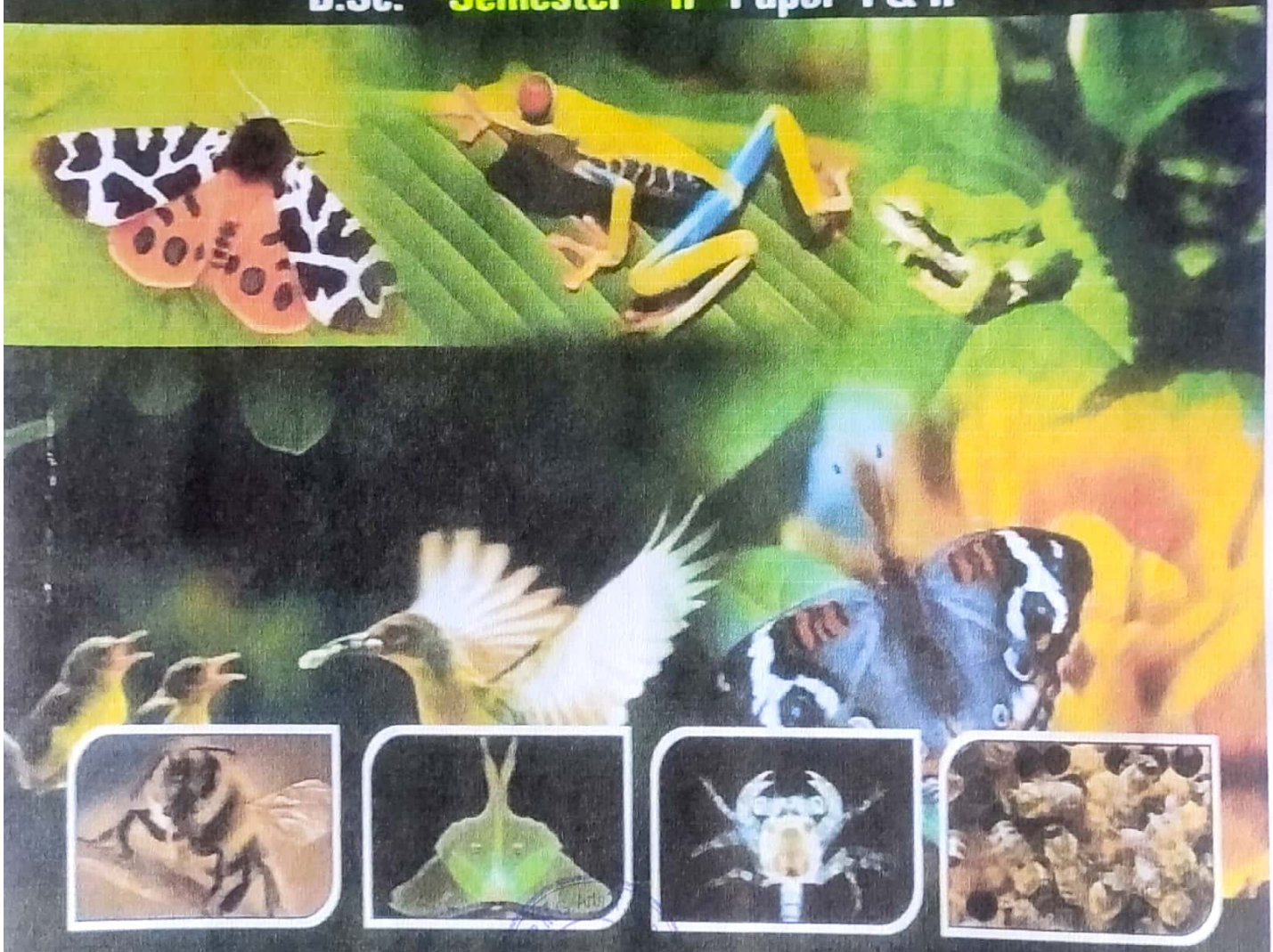

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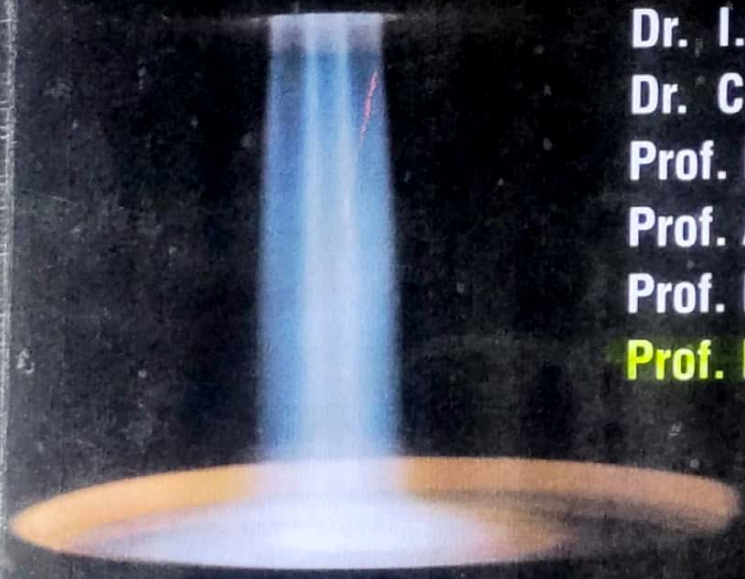

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SYLLABUS

Paper-I (Waves, Acoustics & Laser)

USPHT07: WAVES, ACOUSTICS & LASER

Aim: To make the students to understand the basic concepts Sound Waves, Acoustics and Laser as core part of the subject.

Unit- I (Superposition of two Harmonic Oscillations):

Super position of two SHMs having slightly different frequencies along same line (Beats), Lissajous's Figures, Super position of two Perpendicular Harmonic Oscillations- Graphical and Analytical Methods with equal (1:1) frequencies and unequal (1:2) frequencies, Formation of Lissajous's Figures by CRO and optical method. Application of Lissajous's Figures. Numericals.

Unit- II (Wave Motion and Fourier's Theorem):

Transverse waves on a string, Progressive and standing waves on a string, Normal Modes of a vibration of string, Group velocity, Phase velocity and their relations, Wave intensity.

Fourier's Theorem-statement, evaluation of Fourier coefficients, Its application to saw tooth wave and square wave, Limitations. Numericals.

Unit- III (Ultrasonic and Acoustics):

Ultrasonic waves and its properties, Production by piezoelectric effect, detection, applications (depth of sea, signaling & medical uses).

Noise and music, characteristics of musical sound, Intensity and loudness of sound, Bel and Decibels, musical notes, musical scale, Echo, Reverberation and time of reverberation, Absorption coefficient, Sabine's formula, Requirements of good auditorium. Numericals.

Unit- IV (Laser):

Coherence, spatial and temporal coherence, Einstein's coefficients (absorption, spontaneous and stimulated emission), population inversion, optical pumping, characteristics of laser beam, Ruby laser, Semiconductor laser, He-Ne Laser, applications of lasers. *Numericals.*

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Paper-II (Optical Physics)

USPHT08: OPTICAL PHYSICS

Aim: To make the students to understand the basic concepts of Light Waves and properties of light waves as core part of the subject.

Unit I (Interference of Light):

Definition and Properties of wave front, Huygens Principle of propagation of wave front, Principle of superposition and interference of light, Division of amplitude and division of wave front, Fresnel's Biprism, Phase change on Reflection- Stokes' treatment, Interference in Thin Films: due to reflected and transmitted light in parallel film, Fringes of equal inclination (Haidinger Fringes), Interference in wedge-shaped film, Fringes of equal thickness(Fizeau Fringes). Numericals.

Unit II (Newton's Rings & Michelson's Interferometer):

Newton's Rings: Experimental setup & theory, application of Newton's ring for measurement of wavelength and refractive index.

Michelson's Interferometer- construction and working, types of fringes (circular and localised), Determination of wavelength and Wavelength difference, Refractive index and Visibility of fringes. Numericals.

Unit III (Diffraction):

Basic concept of diffraction, types of diffraction, Fresnel's Diffraction: Definition, Half-period zones, Zone plate, Diffraction due to straight edge and narrow slit. Fraunhofer's diffraction: Definition, Single slit, Double Slit, Diffraction Grating- construction, theory, its application to determine wavelength. Numericals.

Unit IV (Polarization):

Concept of polarisation, Plane polarized light(PPL), production of PPL by reflection, double refraction, Brewster's law, Uniaxial and biaxial crystal, positive and negative crystal, Nicol's prism- construction and working, Nicol as a polariser and analyser, Circular and elliptical polarization, phase retardation (quarter and half wave plate). Numericals.

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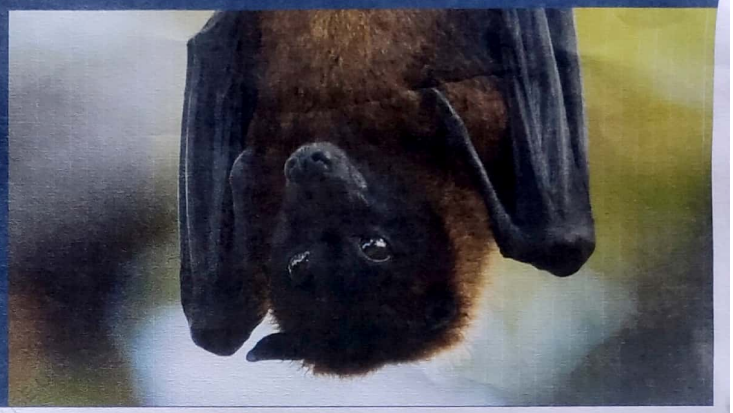
Reproduction is a high priority function of all mammalian species. Strategies used to perpetuate species vary greatly, but in general they evolved to improve the success of survival of the offspring. The reproductive state of an individual at any particular time reflects an integration and coordination of both external and internal signals and not just a simple response to a single environmental factor. I Many mammals are seasonal breeders and respond to annual climatic changes by adaptive alterations in physiological as well as in histoarchitechtural status in anticipation of the coming season. The switching on and off of reproductive functions during the annual breeding cycle of bats is the most striking example of such photoperiodically induced process.Although Chiropterans are the second largest order of mammals, detailed reproductive patterns and their associated changes in the Sertoli cell have been documented only in few species. Hence, present investigation was carried out on Taphozous kachhensis and Pteropus giganteus giganteus of Bramhapuri Forest Range (20060' 80.42"N and 79086 13.36" E) in Chandrapur district of Maharashtra, India Maharashtra, India.



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FINE STRUCTURE OF SERTOLI CELL

FINE STRUCTURE OF SERTOLI CELL OF TWO SPECIES OF INDIAN BATS, TAPHOZOUS KACHHENSIS AND PTEROPUS GIGANTEUS GIGANTEUS

I am working as Assistant Professor at Rashtrapita Mahatma Gandhi College, Nagbhid, Maharashtra (India) and teaching Zoology to Undergraduate students since 18 years. I have till date published 15 research articles and 5 books. I have completed my Ph.D. on the role of Sertoli cell in the reproduction of bat.

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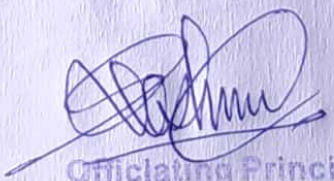

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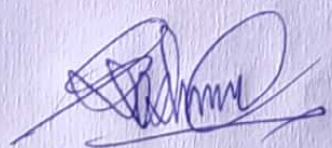

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FINE STRUCTURE OF SERTOLI CELL OF TWO SPECIES OF INDIAN BATS, *TAPHOZOUS KACHHENSIS* AND *PTEROPUS GIGANTEUS GIGANTEUS*

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Preface

Reproduction is a high priority function of all mammalian species. Strategies used to perpetuate species vary greatly, but in general they evolved to improve the success of survival of the offspring. The reproductive state of an individual at any particular time reflects an integration and coordination of both external and internal signals and not just a simple response to a single environmental factor. In order to maximize fitness in terms of an individual's genetic contribution to the next generation different life-history strategies have evolved for which the timing and frequency of reproduction are major determinants. Many mammals are seasonal breeders and respond to annual climatic changes by adaptive alterations in physiological as well as in histoarchitechtural status in anticipation of the coming season. The switching on and off of reproductive functions during the annual breeding cycle of bats is the most striking example of such photoperiodically induced process.

Although Chiropterans are the second largest order of mammals, detailed reproductive patterns and their associated changes in the Sertoli cell have been documented only in few species. In the members of the family Emballonuridae, detailed reproductive patterns have been described in only two species, *Taphozous georgianus* from Australia and *Taphozous longimanus* from India. Bats play an important role in ecosystem balancing and human activities such as arthropod control, pollination and seed dispersing, providing fertilizer and food source etc. (Hill and Smith, 1984). It is therefore important to document and understand the reproductive biology of bats that may be crucial in conservation of this diverse group of mammals. Detailed analysis of reproductive patterns in mega-chiropterans will provide some useful comparisons with primate and micro-chiropteran reproduction. Hence, present investigation was carried out on Taphozous kachhensis and *Pteropus giganteus giganteus* of Bramhapuri Forest Range ($20^0$60' 80.42"N and $79^0$86 13.36" E) in Chandrapur district of Maharashtra, India Maharashtra, India.

Chapter One

Reproduction in bats

The reproductive state of an individual at any particular time reflects an integration and coordination of both external and internal signals and not just a simple response to a single environmental factor. Many mammals are seasonal breeders and respond to annual climatic changes by adaptive alterations in physiological as well as in histoarchitechtural status in anticipation of the coming season. The switching on and off of reproductive functions during the annual breeding cycle of bats is the most striking example of such photoperiodically induced process. (Krutzsch and Crichton, 1990; Gopalkrishna and Badwaik., 1993; Entwistle et al., 1998; Beguellini et al., 2009).

Some well-known environmental factors influencing reproductive timing include food availability, ambient temperature and photoperiod. Although nearly 25% of all mammals are bats, we know very little about how environmental and internal factors interact to regulate annual patterns of reproduction in Chiroptera. (Heidemann, 2000) Bats are also varying greatly in terms of habitat, available foods and mating systems. Pettigrew (1986) and others have suggested that the Micro- and Megachiroptera evolved separately and that the megachiropterans are possibly prosimian primates.

Intra-specific variation has been reported, not just in the timing of reproduction, but also in the periodicity of reproduction in different environments and across the geographic range of the species (Vivier and van der Merwe, 1996). It is therefore often impossible to characterize a specific pattern of reproduction within species with a wide distribution (Bernard and Cumming, 1997). The occurrence of varied reproductive patterns appears to be generally related to major differences in latitude.; Bernard and Cumming, 1997). Bernard and Cumming (1997) identify a limit of 13 °N and 15°S between which most Microchiroptera are either bimodally polyoestrous or aseasonal breeders. The underlying factor determining latitudinal variation in reproductive patterns appears to be differences in the degree in seasonality of climate particularly in rainfall patterns, and corresponding food availability. Variations in reproduction also reflect local differences in patterns of rainfall. (Bernard and Cumming, 1997).

Spermatogenesis in bats, in common with other mammal groups, is highly seasonal at temperate latitudes. The timing of seasonal cycles of male reproduction is not simply a consequence of the timing of female cycles, but also appears to correspond directly to climatic seasonality and food availability (McWilliam, 1988). Seasonal variation in spermatogenesis involves profound

Chapter Two

History of Sertoli cell research

Enrico sertoli used the term mother cells on the 1st page of its his publication (23) suggesting that this cell type served a unique function in its relationship to the developing germ cells. Indeed, Sertoli cell cytoplasm is indented by the germ cell in every stages of the cycle of the seminiferus epithelium, with certain stages showing tremendous indentation or deep crypts and often referred as type A Sertoli cells. Type B Sertoli cells are those that support the movement of elongate spermatids towards the lumen. Thus spermeation appears to separate these two basic structural features of the Sertoli cells. In their morphology, histochemistry and biochemistry as well as in their distribution, the nuclear and cytoplasmic components of Sertoli cells show variations not only with cyclic activity of spermatogenesis but also with the species and seasons as also revealed by recent morphometric analysis (Ueno and Mori,1990; Russel et al., 1990,1994Ye et al., De Franca et al ., 1993;Orsi et al., 1993; Bartke,1994 Guraya,1995,Saidapur and Shanbag,1999, Kolkute and Dukelow,1999).Russell et al. (1994) have made stereological and endocrine studies of hamster Sertoli cells in early testicular regression and early recrudescence. The general lack of Sertoli cell changes in response to a short exposure to inhibitory photoperiod in the seasonally breeding hamster.

Various cytoplasmic components showing species and cyclic or seasonal variations generally show a polarized distribution as evidenced from their abundance in the basal and trunk regions of Sertolil cells whose apical extensions usually show a paucity of organelles (Ueno et al., 1991). Lipid droplets generally surrounded by cisternae of smooth endoplasmic reticulum lie in the basal regions of Sertoli cells. Ye et al. (1993) observed that among the many parameters investigated, only the surface area of the cells, the volume of lipid, and the volume and surface area of the rough endoplasmic reticulum vary cyclically as demonstrated by statistical analysis. The parameters of rough endoplasmic reticulum generally showed a correlation with known patterns of protein secretion within the tubule and with the secretions of specific proteins as wells as the factors important in regulating proteins secretions.

2.1. Cytoskeleton components

Sertoli cell cytoskeleton not only plays some important roles in maintaining cell shape and facilitating intracellular transport but also influences neighboring spermatogenic cells (de-Miguel et

Chapter Three

Materials and Method

Classification of *Taphozous kachhensis*

Class	-	Mammalia
Subclass	-	Theriformes
Order	-	Chiroptera
Suborder	-	Microchiroptera
Family	-	Emballunuridae
Subfamily	-	Taphozoinae
Genus	-	*Taphozous*
Species	-	*kachhensis*

Classification of *Pteropus giganteus giganteus*

Class	-	Mammalia
Subclass	-	Theriformes
Order	-	Chiroptera
Suborder	-	Megachiroptera
Family	-	Pteropodidae
Subfamily	-	Pteropinae
Genus	-	*Pteropus*
Species	-	*giganteus giganteus*

3.1. Collection

The specimens of *Taphozous kachhensis* were collected from the Ambai-Nimbai, caves about 45 km from Bramhapuri, District-Chandrapur, Maharashtra, India(20^{0}38' 39.08"N and 79^{0}35 30.99" E) while *Pteropus giganteus giganteus* from roosting site of Mango trees from Bramhapuri forest range District-Chandrapur, Maharashtra, India(20^{0}60' 80.42"N and 79^{0}86 13.36" E).

Chapter Four

Morphology of testis

The germinal epithelium, is comprised of three distinct components: (1) the Sertoli cells which extends from the basement membrane towards the tubule lumen; (2) the different generations of spermatogenic or germ cells; and (3) the peritubular myoid cells, which envelope the Sertoli cells and germ cells and which are separated from the Sertoli cells by an extracellular matrix or basal lamina. With the evolution of amniotes, a new arrangement of the germinal epithelium emerged (Grier 1993). The cystic pattern of anamniotes is replaced by a new tubular organization in which permanent population of Sertoli cell is present. This restructuring has included profound changes in the cellular relationships that exist during spermatogenesis. Each Sertoli cell is associated with several, developmentally different cohorts of spermatogenic cells. Cohorts of spermatogenic cells are not enveloped by Sertoli cells, as occurs in anamniotes. Rather spermatogenic cells are located laterally between adjacent Sertoli cells with the most immature stages near the base of the epithelium. This produces a structurally complex epithelium consisting of Sertoli cells and multiple stages of developing spermatogenic cells. This tubular organization is present in all modern–day amniote species (Russell, 1993).

Interposed between and attached to the Sertoli cells are the smaller and more numerous germ cells. Because there is a continual production and upward migration of germ cells through the epithelium, each amniote Sertoli cell, at any given point in time, is in contact with many germ cells that are at different stages of differentiation (de Kretser, 1990)

During spermatogenesis, amniote germ cells proliferate and pass through the same series of events seen in anamniote classes. The most immature cells (spermatogonia) are located basally within the epithelium. As they begin the process of differentiation, they gradually become more apically positioned. During this upward migration, cells undergo complete meiosis and enter spermiogenesis. Incomplete cytokinesis during spermatogenesis results in germ cells remaining attached to one another forming isogeic clones that move through the epithelium as units. During spermiogenesis, spermatids become po0sitioned in apical recesses (crypts) of Sertoli cells. It is within these crypts that the germ cells develop the morphological features characteristic of mature

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Chapter Five

Endocrinology of reproduction

Roy Greep (1954), demonstrated the existernce of two anterior pituitary hormones , follilcle stimulating hormone (FSH) and luteinizing hormone (LH), which when administered to hypophysectemized rats could reverse the atrophy of the testis. FSH acted on the seminiferous tubules and LH on the Leydig cells. Subsequent work with purer hormones has confirmed these early concepts, but more recent investigations suggest that the two compartments are not functionally independent and that there is in fact a close and complex interrelationship between them. (Gustafson and Damassa, 1987)

The testis secretes a variety of steroids which are synthesized from cholesterol. The principal secretory product is testosterone, a product of the Leydig cells, which are found in clumps in the intertubular tissue adjacent to the seminiferous tubules. (Payne and Hales, 2004) Testosterone is classified as an androgen since it stimulates male secondary sexual characteristics. The synthesis of testosterone proceeds through a biosynthetic pathway, part of which is common to all the major steroid-secreting endocrine glands, the final end product being determined by the enzymatic composition of the tissue. Testosterone secretion by the Leydig cells is stimulated by LH. Receptors for LH are found on the Leydig cells and in the majority of mammals a rise in LH secretion is followed by a rise in testosterone. (Bernard et al., 1991) In fact, the secretion of both LH and testosterone is episodic and hence quite large changes in the levels of these two hormones may be found over a 24-h period. (Haider et al., 2007)is mediated through the intracellular formation of 3`-5` adenosine monophosphate (cyclic AMP) which in turn stimulates, through a protein kinase mechanism, the activation of numerous cellular reactions, one of which is testosterone secretion. (McLachlan et al., 2002) The enzyme necessary for testosterone production are associated with the mitochondria and smooth endoplasmic reticulum of the Leydig cell. Consequently, long -term LH stimulation results in enlargement of the cell together with increases in mitochondria and smooth endoplasmic reticulum. (Matthiesson et al., 2006) Little is known of the in which testosterone leaves the Leydig cell but it is found in high concentration in spermatic vein, blood , testicular lymph and in the fluid within the seminiferous tubules.

Chapter Six

Ultrastructure of Sertoli cell

6.1.1. Ultrastructure of the Sertoli cell in *Taphozous kachhensis* during sexually inactive period

The Sertoli cell known to change functionally and morphologically at ultrastructural level, during the annual reproductive cycle of mammals, Pudney and Fawcett, (1985) in ground squirrel; Kerr (1988) and Ueno and Mori (1990) in rat; Rune et al., (1992) in marmoset; Munoz et al., (2001) in Viscacha). The Sertoli cells play a major role in regulation of spermatogenesis and altering rates of spermatozoa produced. Sertoli cell functions include providing structural support and nutrition to developing germ cells, phagocytosis of degenerating germ cells and residual bodies, release of spermatids at spermiation and production of a host of proteins that regulate and respond to pituitary hormone release and that influence mitotic activity of spermatogonia (Johnson et al., 2008).

The results of the present study shows that, the Sertoli cells of the *Pteropus giganteus giganteus* and *Taphozous kachhensis* undergo marked nuclear and cytoplasmic changes which conform the change in the hormonal profile during the annual reproductive cycle. During spermatogenesis there are cyclic changes in the structure and cellular organization of germ cells in the seminiferous epithelium along its length. Accompanying these changes, Sertoli cells also show related changes in morphology and function Electron microscope investigation have demonstrated, variations in the nuclear and cytoplasmic components of Sertoli cells not only with cyclic activity of spermatogenesis but also with the species and seasons as also revealed by recent morphometric analysis of different groups of mammals (Dym, (1973) in Monkey; Pudney and Fawcett., (1985) in ground Squirrel; Kerr (1988) and Ueno and Mori (1990) in rat; Rune et al., (1992) in marmoset; Munoz et al., (2001) in Viscacha).

The Sertoli cell extends radially from the basement membrane of the seminiferous tubule upto the lumen of the tubule and adjacent Sertoli cells are separated by the spermatogonia, which also lie in contact with the basement membrane. Fig.6.1 shows, bilobed nucleus which measures 6 µm in diameter. It is bounded by discontinuous nuclear membrane, continuity of which is interrupted by nuclear pore. The nucleoplasm is darkly stained with uniformly distributed heterochromatin. Nucleolus is not observed. The Sertoli cell is involuted to great extent, shows many signs of degeneration at ultrastructural level in the form of vacuoles and phagosomes

Chapter Seven

Role of Sertoli Cell in the reproduction of *Pteropus giganteus giganteus* and *Taphozous kachhensis*

7.1. Morphology of Sertoli cell

The changes in the organization of the germinal epithelium during the annual reproductive cycle are complimented by changes in the morphology of Sertoli cells. In general, Sertoli cells of amniote species are columner in shape. In adult, they form a sessile and non-dividing population of cells that constitutes the major structural elements of the germinal epithelium. (Sinha-Hikim and Bartke, 2005) They are situated on a basement membrane that separates the epithelium from an underlying lumina propria. From this foundation, Sertoli cells extend towards the tubule lumen. Cytoplasmic processes extend from the lateral and apical surfaces of the cell bodies creating irregular contours. Each Sertoli cell varies in shape from its neighbours. The Sertoli cell which is columner in shape and assumed to always extend from the basement membrane of the seminiferous epithelium to the lumen (Pudney and Fawcett,1985; Hess and Franca, 2005), performs its nurse like cell function by extending its cytoplasm in the arm like processes in two dimensions and sheet-like or cylindrical processes in three dimensions around the developing germ cells and forming specialized junctional complexes that consist of gap and tight junctions, actin filaments and smooth endoplasmic reticulum (Dym, 1973; Grove and Vogl, 1989; Griswold, 1998; Guttman et al., 2000; Lee and Cheng, 2004; Hess and Franca, 2005). Approximately 40 % of the Sertoli cell contacts the surface of elongated spermatids (Mruk and Cheng, 2004; Lee and Cheng, 2004), illustrates the extent to which the Sertoli cell stretches its cytoplasm to communicate directly with the developing germ cells.

One significant structural feature that sets amniote Sertoli cells apart from anamiote Sertoli cells and from other epithelial cell types in general, is the position of the inter-Sertoli cell tight junctions. In contrast to other cell types, amniote Sertoli cell form tight junctions with one another close to the base of the epithelium (Skinner, 1991). Consequently, this partitions the germinal epithelium into two compartments (Morales and Clermont, 1993). A small basal compartment, in which most immature germ cells are housed, is formed below the junctions while a larger adluminal compartment, in which the more differentiated germ cells are situated, is created above

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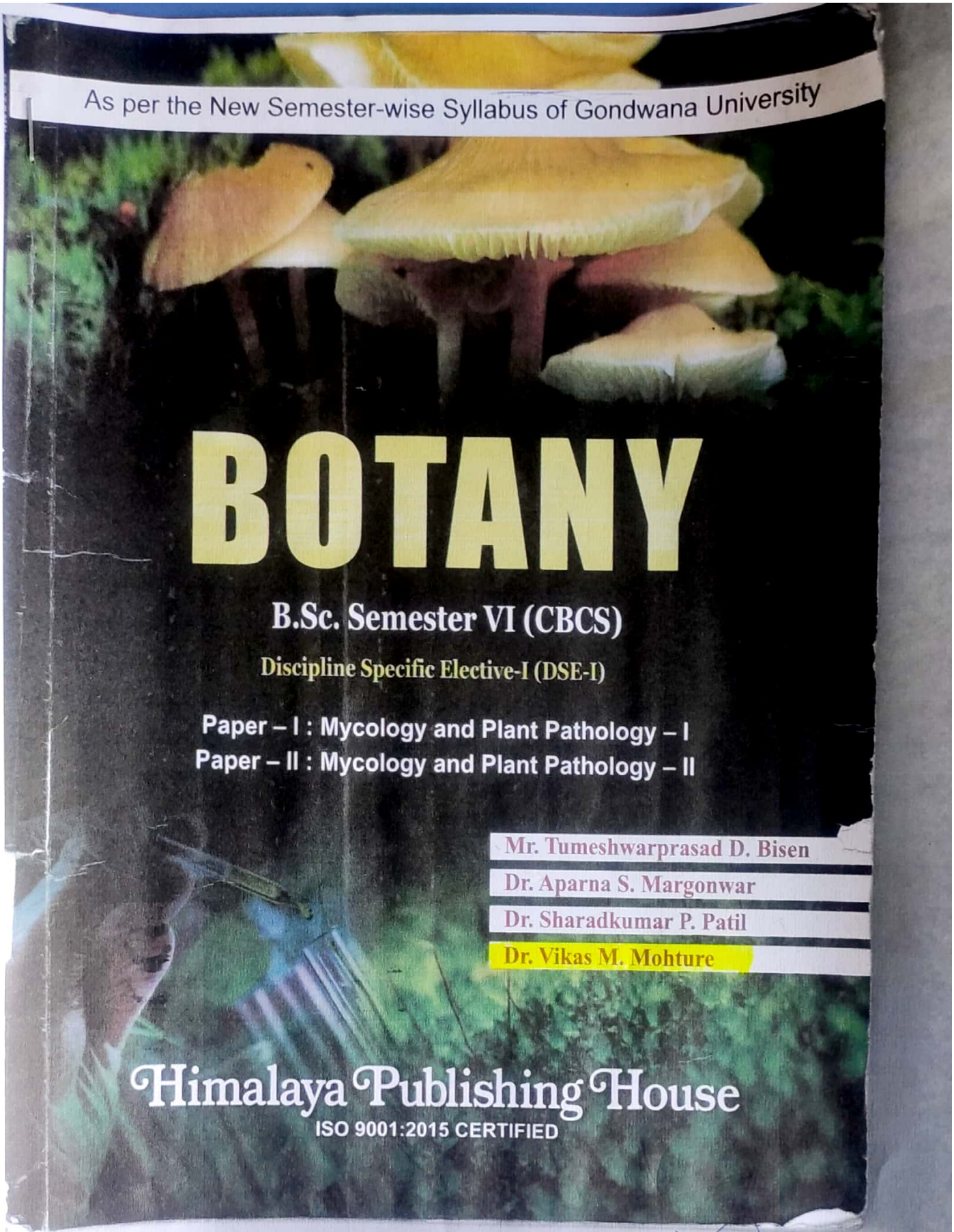

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Paper – II : Mycology and Plant Pathology – II

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